LLNL Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.10: Soil Vapor Surveys—Revision: 4

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CONCURRENCE:	Date
QA Implementation Coordinator	10/2/00

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1.0 PURPOSE

The purpose of this procedure is to describe sampling procedures that will ensure the collection of representative samples and accurate analytical measurements of soil vapor from discrete subsurface depths.

2.0 APPLICABILITY

This procedure applies to *in situ* subsurface soil vapor sampling for volatile organic compounds (VOCs) present in the vadose zone. The outlined procedures are applicable to surveys conducted at the LLNL Livermore Site and Site 300.

3.0 REFERENCES

3.1 Devitt, D. A., R. B. Evans, W. A. Jury, T. A. Stark, B. Eklund, A. Gnolson, and J. J. van Ee (1987), "Soil Gas Sensing For Detection and Mapping of Volatile Organics," *National Water Well Association Publication*, Dublin, Ohio, 270 p.

3.2 Dresen, M. D., E. M. Nichols, R. O. Devany, D. W. Rice, Jr., F. A. Yukic, G. Howard, P. Cederwall, B. Qualheim, R. S. Lawson, And W. F. Isherwood (1989), *LLNL Ground Water Project Monthly Progress Report*—January 1989, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10160-89-2).

3.3 Lamarre, A., N. Crow, S. Vonder Haar, W. McIlvride, R. Ferry, J. Pavletich, R. Caufield, E. Anderson, And M. Wade (1989), "Trichloroethylene Contaminant Plume Definition At The Lawrence Livermore National Laboratory Site 300 General Services Area And Adjacent Ranches, Southeast Of Livermore, California," (Abstract) In Trans., American Geophysical Union Annual Meeting Held In San Francisco, 24 October 89.

3.4 Silka, L. R. (1988), "Simulation of Vapor Transport Through the Unsaturated Zone–Interpretation of Soil-Gas Surveys," *Ground Water Monitoring Review*, pp. 115-123.

3.5 Vonder Haar, S., J. Pavletich, W. McIlvride, and M. Taffet (1989), *Soil Vapor Survey at the LLNL Site 300 General Services Area, Adjacent Portions of the Connolly and Gallo Ranches, and the Site 300 Landfill Pit 6 Area*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-21183), 47 p. plus 1 appendix.

3.6 Vonder Haar, S., R. Ferry, and A. Lamarre (1991), *Comparison of Two Soil-Vapor Survey Techniques and Their Relationship to TCE Concentrations in Underlying Ground Water at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-107360), 67 p. plus 4 appendices.

4.0 DEFINITIONS

See SOP Glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.3 Site Safety Officer (SSO)

Determines the need for protective equipment required to enable the field survey to be conducted in a safe manner. Integrated Safety Management (ISM) procedures will be followed and an Integration Work Sheet (IWS) used as determined by the SSO.

5.4 Soil Vapor Survey (SVS) Project Coordinator

The SVS Project Coordinator is responsible for preparing the SVS Sampling Plan, maps, logistics, technician support and line locators coordination. The SVS Project Coordinator is also responsible for ensuring that the Sampling Plan includes the proper QC samples (i.e., trip blanks, 10% of the sample locations performed in duplicate). Duplicate samples shall be collected sequentially. If needed for a given survey, the SVS Project Coordintor will determine if blank and duplicate samples shall be collected at a minimum at the start of the day's work, about half way through the day's work, and at the end of the day's work. Ten percent of the sample locations will have duplicate samples collected, where appropriate.

5.5 SVS Technician

The SVS technician is responsible for conducting sampling in accordance with this procedure and the sampling plan, conduct all necessary equipment maintenance, and make all required log book entries.

6.0 PROCEDURES

6.1 Discussion

6.1.1 SVSs are used mainly as a tool to indicate the presence of volatile organic compounds (VOCs) in soil vapor as a result of volatilization from the soil and/or ground water. Two distinct SVS methods are used (1) the active vacuum induced (AVI) and (2) the passive collector, such as the GORE-SORBER.

6.1.2 AVI can be used to collect and analyze samples obtained from depths ranging from just below the surface to over 60 feet (see Attachment A). Samples are obtained by first driving a sampling probe assembly into the subsurface to the desired depth. The probe consists of a slotted aluminum drive point attached to Teflon tubing which is threaded through linked hollow-stem stainless steel drive rods. Either a trailer mounted hydraulic drill rig or an electric rotary hammer is used to drive the probe to depth. Then, after exposing the slotted portion of the aluminum point, a vacuum apparatus is attached to the Teflon tubing to draw a soil vapor sample to the surface for collection. Samples are analyzed using either a portable gas chromatograph (GC) for individual chemical compound identification and quantification or an organic vapor analyzer (OVA) for a total VOC measurement. This technique provides quantitative contaminant concentrations reported in parts per million $(ppm)_{V/V}$. Samples may also be sent off site for analysis after collection in an appropriate container.

6.1.3 The GORE-SORBER passive soil-vapor technique provides a means to collect and detect trace quantities of a broad range of VOCs and semi-volatile organic compounds (SVOCs) near the ground surface (see Attachment B). The GORE-SORBER collector and methodology are described in detail in Attachment B. It is strongly recommended that site activities that disturb the natural equilibrium of soil gas migration not be conducted during the time when the modules are in the subsurface. Such activities include: drilling (especially air-rotary), installation/operation of soil vapor extraction systems, construction or excavation, air sparging, etc.

6.2 Office Preparation

6.2.1 Collect the equipment and materials needed to conduct the survey per Attachment B for GORE-SORBERs.

6.2.2 Obtain a soil vapor sampling station location map from the SVS Project Coordinator (see Attachment E of this SOP for an AVI SVS sampling station example). Obtain a logbook from the Document Control Officer per ERD SOP 4.2 "Sample Control and Documentation." The Subproject Leader (SL) or designee reviews the existing vapor, soil, and ground water data and plots the locations of the contaminant plume(s), roads, buildings, utilities, etc. on a map to determine the grid pattern and line spacing for the sample points.

The SL or designee selects the appropriate compound specific survey and required analyses from standard or custom lists.

6.2.3 Verify with the SVS Project Coordinator that the soil vapor stations have been properly cleared by an underground line locator and a "Site2/300 Plant Engineering – Soil Excavation" permit received.

6.2.4 Read and understand the site safety plan and any applicable Integration Work Sheets (IWSs). Obtain any necessary safety equipment.

6.2.5 Review all applicable SOPs with field personnel.

6.3 Field Preparation

Record required information on the Daily Field Report and the SVS Analytic Data Sheet (see SOP 1.1, "Field Borehole Logging", Borehole/Well Construction Log, Attachment D and Attachment F, SVS Analytic Data Sheet in this SOP). Make appropriate entries into the SVS field logbook.

Mark proposed sample locations on ground with stakes in undeveloped areas and with spray paint on pavement. Pre-drill holes for larger projects to speed module installation.

Ensure proper storage of GORE-SORBER Modules until deployment in the field. **DO NOT** store them near potential sources of organic vapors including petroleum fuels, fuel exhaust, solvents, paints, adhesives, foam insulating materials, etc.

Gather required tools and sampling supplies

- Slide hammer slam bar, or electric rotary drill to obtain 1/2-inch to 1-inch diameter and three foot deep pilot.
- Stainless steel insertion rod (supplied by W.L. Gore & Associates). Obtain extra rods for large projects.
- Corks with attached screw eyes (supplied by W.L. Gore & Associates).
- String cord to allow installation of module to desired depth (supplied by W.L. Gore & Associates).
- Chain of Custody and Installation/Retrieval Log forms (supplied by W.L. Gore & Associates).

6.4 AVI SVS Operation

The AVI SVS procedure consists of three major operations: (1) station set-up, (2) sample collection, and (3) sample analysis. Each step has two possible approaches making a total of eight available modes of operation. The mode selection criteria include the specific field conditions and analytical requirements of the particular survey.

6.4.1 AVI Sampling Station Set-Up

A. Drill rig installed SVS station

This method is especially useful for sample depths greater than 5 ft. Generally, a trailer-mounted auger rig is employed to install the sampling probes. However, a full-size drill rig can be used to reach greater depths.

1. Set up the rig at the selected SVS station. Verify the location has been marked as being cleared by the underground utility line locator before proceeding.

2. Drill a borehole within 2 ft of the desired sampling depth. Specific soil conditions may require an adjustment of this measure. Note the borehole depth in the field logbook.

3. Assemble the sampling probe:

    a. Connect enough lengths of stainless steel drive rods together to reach the desired sample depth. Only use rods which have been decontaminated according to SOP 4.5, “General Equipment Decontamination.” Attach the side-port adapter which allows the Teflon tubing to exit the sampling probe assembly.

    b. Attach an aluminum drive point to a length of Teflon tubing by crimping the top potion of the drive point onto the terminal 1 in. of the tubing. The tubing length should be approximately 3 ft greater than the drive rod length. Use only new aluminum drive points and Teflon tubing at each sample location.

    c. Thread the Teflon tubing into the bottom end of the drive rod assembly until the aluminum drive point seats into the rod. Assure the other end of the tubing has exited the probe through the adapter at the top of the drive rod assembly.

4. Place the sample probe into the borehole assuring that the aluminum drive point remains seated inside the drive rod. If it does not, remove the probe from the borehole, reseat the aluminum point, and secure the tubing at the side port adapter with Teflon tape to eliminate slippage; reinstall the probe.

5. Connect the adapter at the top of the probe to the drill rig drive assembly and hydraulically drive the tip of the sampling probe to the desired depth. Note the final depth in the field logbook.

6. Expose the slotted portion of the aluminum drive point by hydraulically lifting the drive rods about 2 in. with the drill rig. Ensure the drive point has remained at depth while the rods were lifted. This is accomplished by holding or marking the Teflon tubing and assuring that it slips down into the adapter as the drive rods are being lifted. It is critical to perform this step correctly to obtain a representative sample.

7. Backfill the borehole with auger cuttings and pack the soil around the drive rods tightly to seal off the hole. If necessary, clamp a vise grip to the drive rod at ground level to keep the rod from slipping back into the hole.

8. Disconnect the sample probe from the drill rig and remove the sideport adapter. Seal the Teflon tubing's exit point out of the drive rod with Teflon tape to prevent dilution of the soil vapor sample with outside ambient air.

Note: Attachment A refers only to a dedicated type of soil vapor installation, not to a one-time installation as described in Steps 7 and 8 above.

B. Rotary hammer installed SVS station

This method is useful in areas that are inaccessible to a drill rig.

1. Set up the rotary hammer equipment at the sampling location placing the generator downwind. Verify the location has been marked as cleared by the underground utility line locator before driving the sampling probe.
2. If necessary, drill a pilot hole through concrete or asphalt surfaces using the rotary hammer and an auger bit.
3. To assemble the sampling probe see Section 6.4.1, A-3.
4. Set the rotary hammer to impact only (rotary drive off) then connect it to the sample probe adapter and place the probe tip into the pilot hole.
5. Drive the tip of the sampling probe to the desired depth. Note the final depth in the field logbook.
6. Verify the Teflon tubing has remained connected to the aluminum drive point by gently pulling on the tubing. If it has not, remove the rod and repeat the sample station installation procedure.
7. Expose the slotted portion of the aluminum drive point by lifting the drive rod about 2 in. with the hydraulic jack. Ensure the drive point has remained at depth while the rod was lifted. This is accomplished by holding or marking the Teflon tubing and assuring that it slips down into the adapter as the drive rod is being lifted. It is critical to perform this step correctly in order to obtain a representative sample.
8. Disconnect the sample probe from the rotary hammer and remove the sideport adapter. Seal the Teflon tubing's exit point out of the drive rod with Teflon tape to prevent dilution of the soil vapor sample with outside ambient air.

6.4.2 AVI Sample Collection

A. Direct Sampling

This method is used primarily in conjunction with portable GC analysis. An OVA can also be used but any sample stream flow restriction may cause erroneous readings.

1. Estimate the soil vapor concentration range by connecting an OVM/PID to the Teflon tubing exiting from the sampling probe. This pre-screening will be useful in determining analytical instrument sensitivity settings. Record measurements on the SVS Analytic Data Sheet.

2. Using a 2-in. length of flexible Teflon tubing, attach a low-flow portable vacuum pump to the Teflon tubing assuring a leak-free connection. Use new silicone tubing at each sample location.
3. Start the vacuum pump and adjust sample stream flow to 200 mL/min. Note any flow restrictions in the field logbook and SVS Analytic Data Sheet.
4. Allow a 5-min purge time to remove ambient air from the tubing. (Deep points may need longer purge times.) The 5 minute or longer purge time was determined by our field analysts based on the volume of ambient air in the Teflon tubing and taking sequential samples for analysis.
5. Using a syringe, collect a sample for direct injection GC analysis by inserting the needle through the silicone tubing, pumping the syringe plunger several times, then slowly drawing in the vapor sample.

B. Vacuum Chamber

This method is used primarily in conjunction with the portable OVA since it eliminates measurement errors caused by sample stream flow restrictions. This method is also useful in collecting samples to be sent to an analytical laboratory for analysis.

1. Install a clean sample bag (Tedlar or equivalent) into a vacuum desiccator which has been modified to allow a sample line to pass through the exterior wall. Verify the sample bag is clean by conducting a “bag blank” test using zero grade air prior to use.

2. Close the vacuum chamber, connect the Teflon sample tubing to the inlet port, and the attach the vacuum pump to the outlet.

3. Initiate sample collection by evacuating the internal canister air using the vacuum pump. Adjust the pump flow rate to 200 mL/min.

4. After an appropriate volume of sample has been collected, close the sample inlet valve, stop the pump, release the vacuum, and remove the sample bag. The volume of sample to be collected will be determined on a case-by-case basis by discussion with the analytical laboratory.

6.4.3 AVI Analytical Instrumentation

A. Portable GC

A portable GC can be used for analysis when identification and quantification of a sample’s constituent compounds is desired. Follow the instrument manufacture’s guidelines for use of the portable GC.

1. Only properly trained personnel should conduct analyses using the GC.

2. If possible, set up a field laboratory in a building, trailer, or vehicle to provide stable operating conditions for the GC.

3. Using a syringe, obtain a sample for injection into the GC by either direct inline withdrawal or from a sample bag; both collection techniques are described above in Section 6.4.2, AVI Sample Collection.

B. OVA

The OVA is used when only a total VOC concentration value is necessary. However, a GC column can be installed on some OVAs allowing more sophisticated analyses. The OVA requires less intensive operator training than the Photovac GC.

1. Follow the OVA operating instruction as described in the OVA manual. Only trained OVA operators should use this instrument for analyses.

2. Calibrate the OVA per SOP 4.8, “Calibration/Verification and Maintenance of Field Instruments Used in Measuring Parameters of Surface Water, Ground Water, and Soils.” Record calibration information on the SVS Analytic Data Sheet and in the logbook.

3. Samples collected in bags are analyzed by connecting the metal OVA probe to the sample bag and recording the maximum reading. Record the value on the SVS Analytic Data Sheet and note any unusual instrument response.

4. Readings that show an initial upward jump of the scale’s pointer followed by a sudden bottoming-out indicate an extinguishing of the detector’s flame. This is caused by either extremely high sample concentration or lack of oxygen in the sample. Follow the operating instructions to relight the detector.

6.4.4 AVI SVS Station Breakdown

A. Remove steel rod from the ground with either the trailer-mounted rig or the hydraulic jack. The stainless steel sampling rods should be cleaned between sites with detergent and hot water as per SOP 4.5.

B. Remove the Teflon tubing from the ground. If the total VOC soil vapor concentration was unusually high, consult with the SVS Project Coordinator before removing the tubing.

C. Backfill the hole with native soil. If necessary, cap the hole with asphalt patch or concrete to match the existing surface.

D. Mark each sample location with a wooden stake, spray-paint or similar identification device. Measure the distance between sample locations using a suitable measuring device and record these distances on a sample location map. Include distance measures to permanent or surveyed landmarks (buildings, monitoring wells, etc.). Orient the map by taking a compass reading. If desired, a survey team may be employed to map the sample locations.

6.5 Passive GORE-SORBER SVS Operation

6.5.1 Module Installation

- Drive/drill a 1/2- to 1-inch diameter pilot hole to a depth of three feet below grade.

- Wearing surgical gloves, remove the GORE-SORBER Module from the numbered container and re-seal the jar. Verify that the module ID number matches the ID number on the container.
- Follow GORE Procedure (Attachment B).
- When working in pavement an “eye” screw can be screwed into the top of the cork to facilitate removal.
- DI water can be sprayed on a dry soil surface before the tile probe is used to help with installation.

Note: Modules can be hung above ground to sample ambient air to aid in background and QA concerns. And, modules can be hung in vadose zone wells to sample vapor in the well-bore.

6.5.2 Module Retrieval

The SVS Project Coordinator determines the module exposure period, which is usually 10 to 21 days. (Note: 21 days is preferred for TCE, DCE, PCE, and related VOCs)

- Follow GORE Procedure (Attachment B).
- Holes can be grouted as needed, especially in pavement areas.

6.5.3 Documentation and Shipping

- Document field activities an provide original documentation/forms to Data Management Team (DMT).
- Complete “Gore-Sorber Screening Survey Installation and Retrieval Log” form.
- Complete “Gore-Sorber Screening Survey Chain of Custody ” form.
- Obtain “University of California – Shipping Document” from Technical Release Request (TRR).
- Submit samples to LLNL Shipping Department (Building 411 – Room 1608) for delivery using overnight courier.

6.6 Post Operation

6.6.1 Decontaminate and store equipment properly per SOP 4.5.

6.6.2 Review logbooks and field forms for completeness and accuracy per SOP 4.2.

7.0 QUALITY ASSURANCE RECORDS

7.1 Final Analytical Data (either in µg/sorbant or $ppm_{v/v}$).

7.2 Field Logbooks

7.3 Daily Field Report

7.4 SVS Analytical Data Sheet

7.5 Chain-of-Custody forms

8.0 ATTACHMENTS

Attachment A—Figure of a Dedicated Soil Vapor Monitor Point used for AVI

Attachment B—Passive GORE-SORBER Methodology for Module Storage, Installation, and Retrieval Including Figures

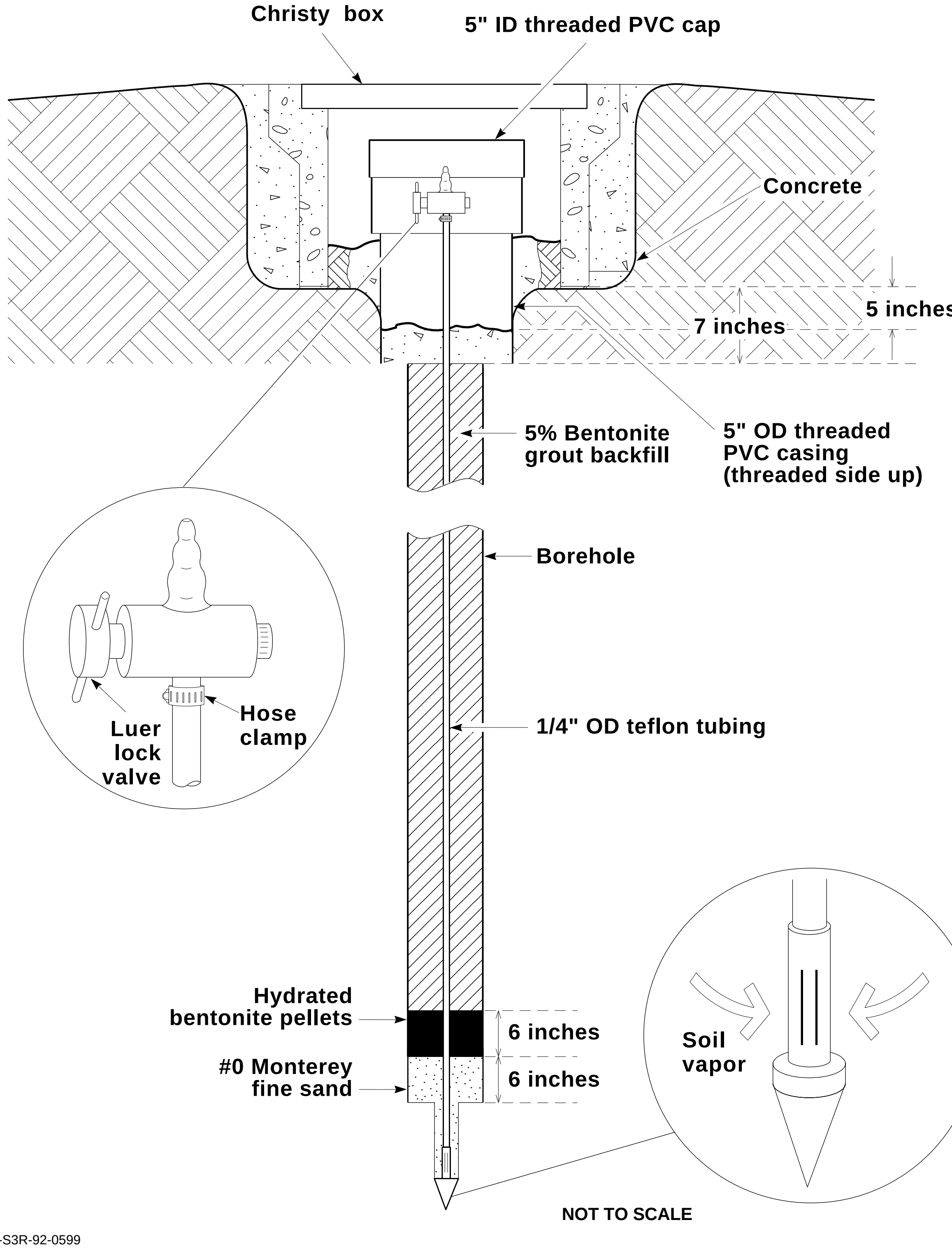
Attachment C—Equipment Checklist

Attachment D—SVS Sampling Station

Attachment E—SVS Analytical Data Sheet—OVA

Attachment A

Figure of a Dedicated Soil Vapor Monitor Point used for AVI



Attachment A. Dedicated soil vapor monitor point used for AVI.

Attachment B

Passive GORE-SORBER Methodology for Module Storage, Installation, and Retrieval Including Figures

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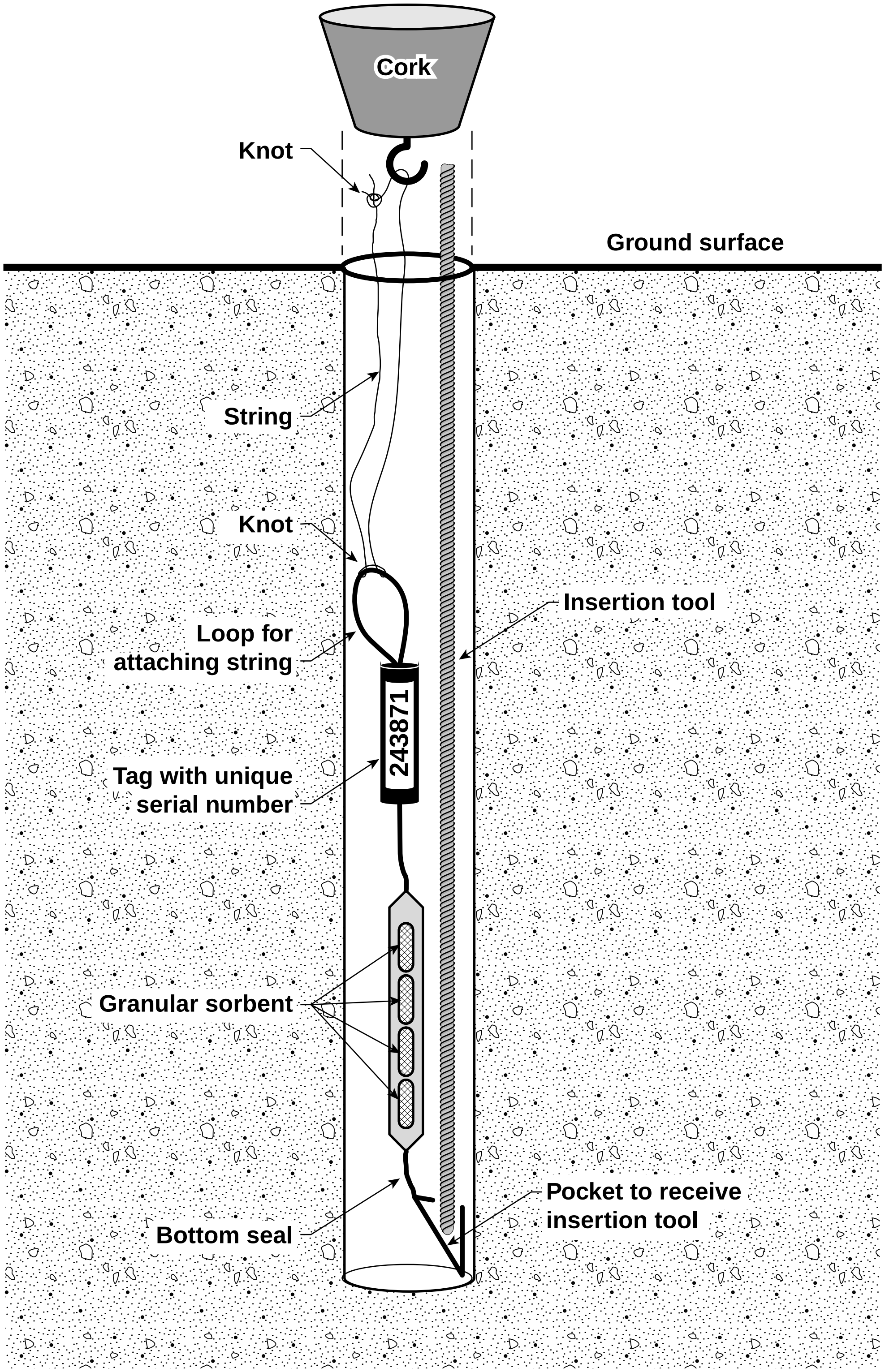

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Figure 1. Gore-Sorber® module installation schematic.

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Attachment C

Equipment Checklist

EQUIPMENT CHECKLIST

General Materials
____Aluminum foil
____Broom and dust pan
____Chalk
____Compass
____Container for H_2O
____Ear plugs
____Extension cord
____First aid kit
____Flashlight
____Garbage bags
____Geologist's hammer
____Work gloves and sampling gloves
____Handiwipes
____Lab soap
____Logbook
____Maps (site and sample location)
____Measuring tape and/or wheel
____Mixing bucket
____Notebook and clipboard
____Pens
____Personal protective equipment
____Pin flags or wooden stakes
____Pliers and wire snips
____Poly rope and/or HIP chain
____Quick-plug cement
____Ribbon flagging
____Engineer's scale and calculator
____Safety glasses
____Scissors
____Scrub brush
____Shovel
____Spray paint
____Tool box
____Trowel and spatula
____Utility bucket
____Vice grips

AVI SVS Materials
____3/4-5/8-in.-diam. stainless steel drive rods
____Aluminum drive points
____Teflon tubing
____Sideport tubing exit adapter
____Teflon tape
____Low-flow portable vacuum pump
____Analytic data sheets
____1L Tedlar bags
____Hot plate

Photovac specific materials:
____Photovac GC and accessory equipment
____Zero-grade air
____Gas-tight syringes, assorted sizes
____1-liter mega syringe
____Calibration gas

OVA specific materials:
____OVA
____Hydrogen gas (for detector)
____Modified desiccator/pump assembly
____Methane calibration gas
____Sample bags

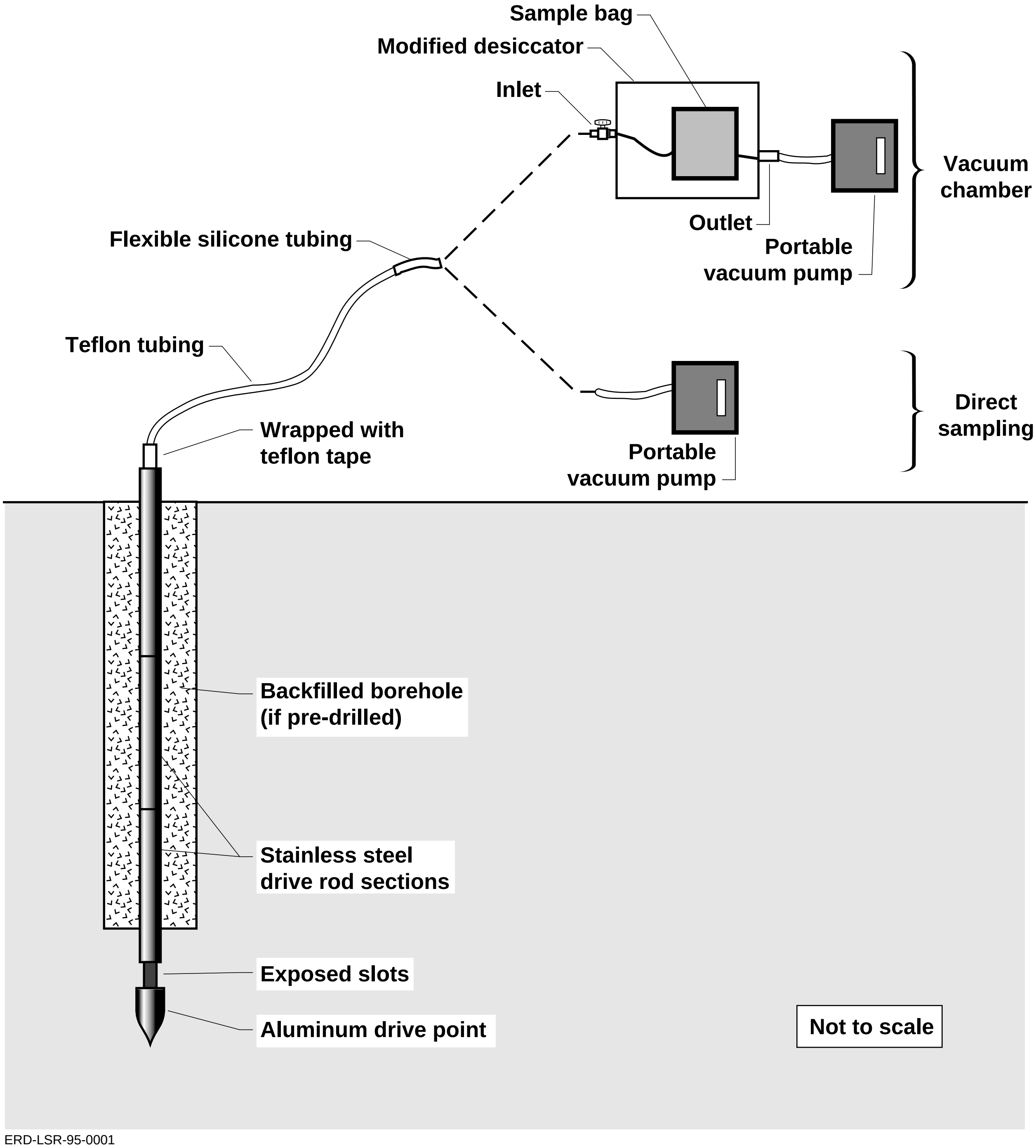
Drill rig specific materials:
____Trailer mounted or full-size drill rig
____Augers and supporting equipment

Rotary hammer specific materials:
____Rotary hammer (or jack-hammer)
____Hydraulic jack and rod connector
____Hand auger
____Generator

PETREX Materials
____Air-tight plastic bags
____Bubble wrap
____Chain-of-Custody forms
____Chisel
____Cooler
____Coring shovel
____Coring tube with 8 lb sledge hammer
____Dolly
____Duffel bag(s) (carry-on size)
____Extra Petrex tubes (empty) with caps
____Clean forceps
____Generator (plus gasoline container)
____Hammer drill (plus 2 bits)
____Knee pads
____Labels
____Machete
____Packing tape
____PETREX collectors with caps
____15 time tests, 5 blanks, extras
____Pliers (needle nose)
____Retrieval wire (baked)
____Screwdriver (large flat)
____Spatula
____Time test/retrieval protocol sheet
____Tongs
____Wire snips
____Wooden dowel

Attachment D

SVS Sampling Station



Attachment D. SVS Sampling Station.

Attachment E

SVS Analytic Data Sheet—OVA

SVS Analytic Data Sheet—OVA

Survey Area________________________________ LLNL Doc. Control no.____________________________

Survey Date______________ Analyst Name___________________________________

Sample ID no.	Time Samples	Ambient Air Temp. (˚F)	Ambient Air Measurement	Bag Blank Measurement (ppm [v/v])	Sample Measurement (ppm [v/v])	Comments